

Determination of Local Site Effects in Taikkyi Area, Yangon Region by using Microtremor Observations

Ohnmar Khine, Kyaw Kyaw

Department of Civil Engineering, Yangon Technological University, Yangon, Myanmar

ABSTRACT

Considering the possible local site effect is one of the most important facts in seismic hazard assessment. Depending on the local site condition, the characteristics of the seismic waves propagated through different geological layers and amplified the surface ground motion. In this study, one of the geophysical method of microtremor observations were carried out at 112 sites throughout the Taikkyi area. After analyzing the recorded microtremor observed data by Cygwin Software, we determined the horizontal to vertical spectral ratio (HVRs) that reflects the local site effects of the study area. The main outcomes of this research is to develop the fundamental frequency map and peak amplitude or soil amplification map of Taikkyi area. According to the evaluation results, the fundamental frequency is ranging from 1 to 2.3 Hz and most parts of Taikkyi area show in the range of 1.3 to 1.6 Hz. The peak amplitude of HVRs (potential soil amplification) is ranging from 1.5 to 3.6 and most parts of the area are in the range of 1.5 to 2.5.

KEYWORDS: microtremor, Horizontal-to-Vertical Spectral Ratio (HVRs), fundamental frequency, peak amplitude

How to cite this paper: Ohnmar Khine | Kyaw Kyaw "Determination of Local Site Effects in Taikkyi Area, Yangon Region by using Microtremor Observations" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-5, August 2020, pp.1591-1595, URL: www.ijtsrd.com/papers/ijtsrd33203.pdf



IJTSRD33203

Copyright © 2020 by author(s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



I. INTRODUCTION

Myanmar is exposed to a major earthquake since it lies in the Alpide Earthquake Belt, one of the two main Earthquake Belts of the world. According to the historical seismic events, the main seismic sources for earthquake potentials in Myanmar are subduction zone Indian Plate beneath Burma Plate, Sagaing fault and Kyaukkyan fault. The well-known active Sagaing fault is trending roughly north-south, which may cause large destructive earthquakes in Myanmar. Therefore, Myanmar is an earthquake prone country and is vulnerable to hazards from moderate to large magnitude earthquakes.

The study area, Taikkyi is located in the northern part of Yangon and this area is also near West Bago Yoma fault and Saging fault. Taikkyi is frequently suffered from the moderate earthquakes with magnitude, M_w 4 to 5. In 2017, a moderate earthquake with magnitude 5.1 occurred near Taikkyi area on 13 March. Taikkyi is the most severe affected by this earthquake and after the main shock, average magnitude of less than 4.5 occurred on the following days. Due to this moderate powerful earthquake hit near Taikkyi, not only some old houses, pagodas and other religious buildings were damaged but also Gyophyu reservoir, which is located in Taikkyi township and its water intake tower, pipe supports and some of brick masonry staff housings were also damaged. Figure.1 and 2 show some of damages occurred in Taikkyi area after 2017 Taikkyi earthquake.



Fig.1 Some Pagodas and Religious Buildings Damages due to 2017 Taikkyi Earthquake



Fig.2 Gyo Phyu Pipe Line Movement and Pipe Support Damages after 2017 Taikkyi Earthquake

Therefore, the variations in ground motion according to local geological site conditions in Taikkyi area is needed to investigate. The purpose of this study is to determine the fundamental frequency and peak amplitude that reflect the local site conditions of the Taikkyi area.

II. STUDY REGION

Taikkyi, located in the northern part of Yangon district, is situated at latitude $17^{\circ}30'0''$ N and longitude $96^{\circ}02'00''$ E. The location of the study area is shown in Figure 3.

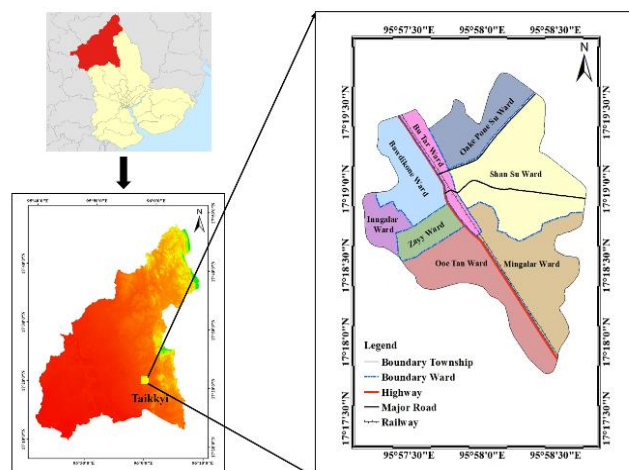


Fig. 3 Location Map of the Study Region

Taikkyi is located low to medium seismicity region. Taikkyi is also near the main seismic sources of the Indian-Burma plate's subduction in the west, West Bago Yoma fault in the north east and Sagaing fault in the east. The geological structure of Taikkyi area is underlain by alluvial deposits of Bago Yoma fan. The alluvial deposits can be found in the flood plains and they have the texture of gravel, clay, silts, sand and laterite. [3]

Taikkyi is mainly composed of eight wards; Bu Tar, Oake Pone Su, Shan Su, Mingalar, Bawdikone, Inngalar, Zayy and Ooe Tann ward. To develop the fundamental frequency and soil amplification map, geophysical measurements were observed for these eight wards to cover the whole study region.

III. MICROTREMOR OBSERVATIONS

The surface of the earth is always in motion at seismic frequencies, even without earthquakes. These constant vibrations of the earth's surface are called microseisms or microtremors and its amplitude is generally too small (10^{-4} to 10^{-2} mm) to be felt by human senses. (Okada, 2003) Microtremor represents a low energy wave field consisting of interfering wave propagation from a range of different sources and directions at many frequencies. Microtremors with frequencies above 1 Hz are generally associated with man-made cultural sources, while those below 1 Hz are associated with natural phenomena.

There are two methods that can be applied in microtremor measurement method. The first method is the single station method, where a three component record from a single geophone is processed to provide a spectrum of horizontal to vertical particle motion ratio. Another method is the array measurement method, which can obtain the propagation velocities of Rayleigh waves by measuring plural instruments simultaneously. In this research, applications and interpretation of single station microtremor method proposed by Nakamura (1989) is used. According to Nakamura, 1989, the microtremor measurements can be used to determine the characteristics of ground motions. Therefore, the characteristics of measured microtremor data is very useful to quantify the effects of local geological site conditions and dynamic characteristics of the subsoil.

The HVRs or Nakamura's technique, which is simply based on calculation of spectral ratios of Fourier spectra of horizontal to vertical microtremor velocity components to determine H/V spectral ratio and is especially recommended in low to moderate seismicity areas. There are generally five steps consist in evaluation of H/V spectral ratio: (1) Separation of acceleration time historical data (2) Processing for 40.96 sec recorded microtremor data (3) Performing Fast Fourier Transform (4) Calculation of microtremor spectra for NS/UD and EW/UD components and (5) Evaluation of observed microtremor spectrum of H/V spectral ratio by taking the average of NS/UD and EW/UD of microtremor spectra. This H/V spectral ratio can be easily applied to estimate the fundamental frequency and peak amplitude (potential soil amplification) of subsurface soil structure which are closely related to the geological conditions of the site under study.

A. Microtremor Measurements throughout Taikkyi Area

The single station microtremor measurements in Taikkyi area were carried out by using the SMAR-6A3P microtremor instrument with LS 8800 data logger as shown in Figure 4. The sampling frequency was set at 100 Hz for all measurements and the global positioning system (GPS) was used for time calibration. The site to site distance is approximately 200 meter and the duration of the record time was 30 minutes. Figure 5 shows the single station microtremor measurement performing in Taikkyi. During the measurements, the recordings must be free from local noise sources, like e.g. passing pedestrians, vehicles or operating machineries. Meteorological disturbances, e.g. rainfall or gusty wind did not occur during the observation period.



Fig. 4 SMAR-6A3P Microtremor Instrument



Fig. 5 Single station microtremor measurement in selected site of Taikkyi

To provide enough spatial distributions of the study area, the single microtremor observations of 112 sites were measured as shown in Figure 6.

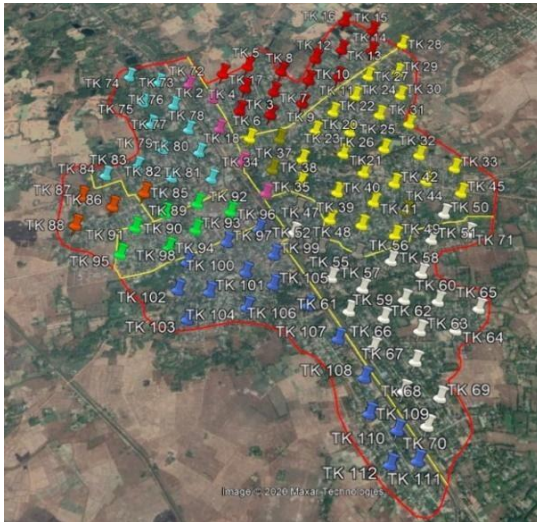


Fig.6 Locations of the Measurement Points in Taikkyi Area

IV. MICROTREMOR OBSERVED DATA AND ANALYSIS RESULTS

A full microtremor record can be described by one vertical, UD component and two horizontal components, NS and EW component. The spectral ratio of horizontal to vertical motion obtained by microtremor observations is called H/V spectral ratio.

In this study, microtremor measurements were conducted at 112 sites and each site was measured for thirty minutes. After digital signal processing and analyzing the microtremor data for thirty minutes for each site, we selected the good microtremor spectra from the results of each ten minutes for the components (NS/UD and EW/UD) as shown in Figure 7.

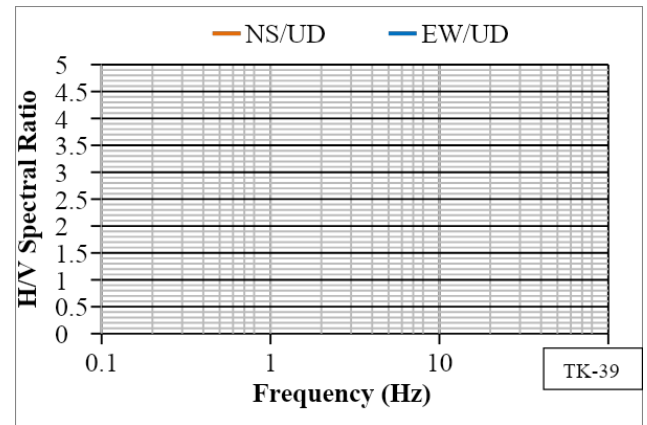


Fig.7 Microtremor Spectra of NS/UD and EW/UD Components for the Selected Sites, TK-34, TK-73 and TK-39

And then, the observed microtremor spectrum is calculated by averaging the spectra of NS/UD and EW/UD components. Figure 8 represents the observed microtremor spectrum for the selected sites.

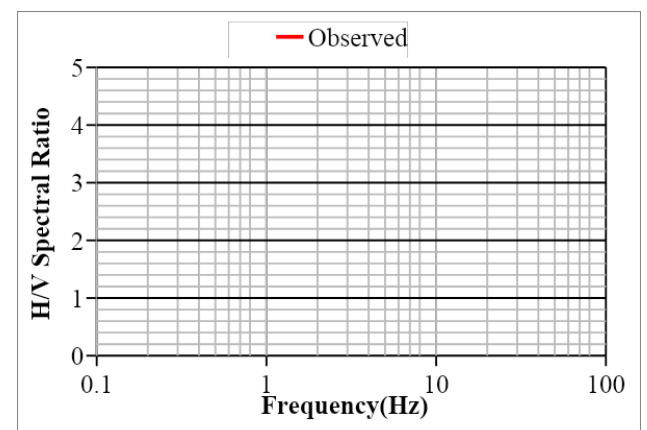
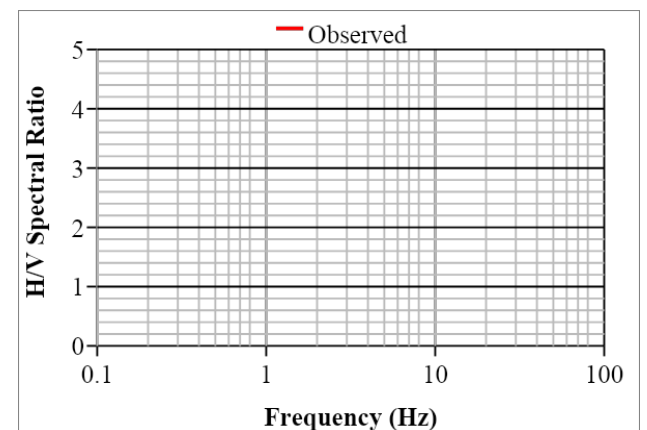
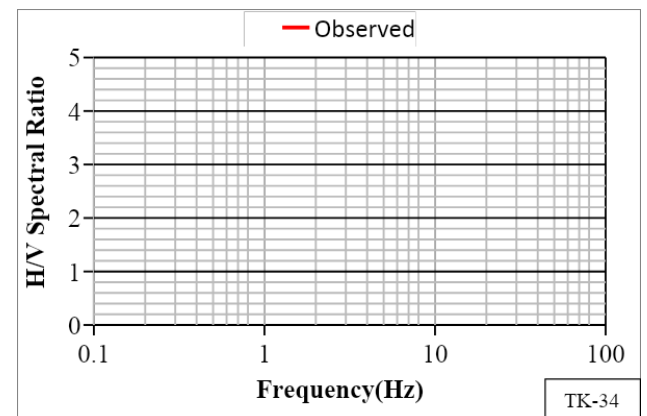


Fig. 8 Observed Microtremor Spectra of Selected Sites, TK-34, TK-73 and TK-39

A. Determination of Fundamental Frequency and Peak Amplitude (Soil Amplification)

In microtremor method, site effects are usually represented in the form of frequency and peak amplitude. In this research, based on the observed microtremor spectrum obtained from the microtremor measurements, the peak amplitude of H/V spectral ratio or potential soil amplification and fundamental frequency had been determined for each site.

The fundamental frequency of the ground shows the geological structure of the local area since the fundamental frequency has a relation to the soil thickness of the underlying soil layers. Based on the analysis of fundamental frequency calculated for all sites, we have prepared the fundamental frequency map as shown in Figure 9. According to this map, the frequency is ranging from 1 to 2.3 Hz and most of the fundamental frequency are observed in 1.3 to 1.6 Hz. In this map, red colour represents the highest fundamental frequency zone and yellow colour represents the lowest frequency zone. High frequency zone is dominated by shallow soil layers and observed lower frequency zone can be expected by thicker sediment layers.

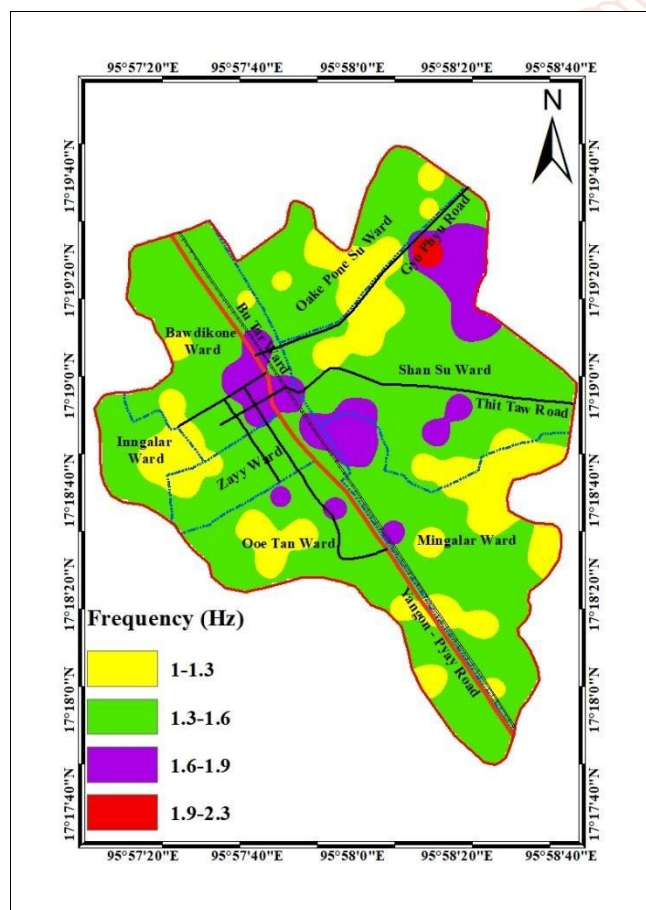


Fig.9 Fundamental Frequency Map of Taikkyi Area

Amplification of the ground motion refers to the increase in the intensity of ground shaking that can occur due to local geological conditions. During an earthquake, seismic waves are released at the source and propagated through different geological layers and then they amplified the surface ground shaking depending on the local site conditions. Based on the fundamental peak of the observed microtremor spectrum, the peak amplitude of H/V spectral ratio is regarded as the potential soil amplification of the measured site and soil amplification map is developed as shown in Figure 10.

According to this map, the peak amplitude (soil amplification) is observed to be ranged generally for 1.5 to 3.6 and most parts are in the range of 1.5 to 2.5. In this map, red colour represents the highest amplitude zone and yellow colour represents the lowest amplitude zone. Larger potential soil amplification can be expected in high peak amplitude zone and strong ground motion can occur in this zone. After 2017 Taikkyi earthquake, monasteries in Bu Tar ward and Mingalar ward were severely affected and many damages occurred due to this earthquake. It is found that the peak amplitude of HVRs value in these sites are encountered in highest amplitude zone. Therefore we notice that soils with lower shear wave velocity generally greater amplification than the soils with higher shear wave velocity.

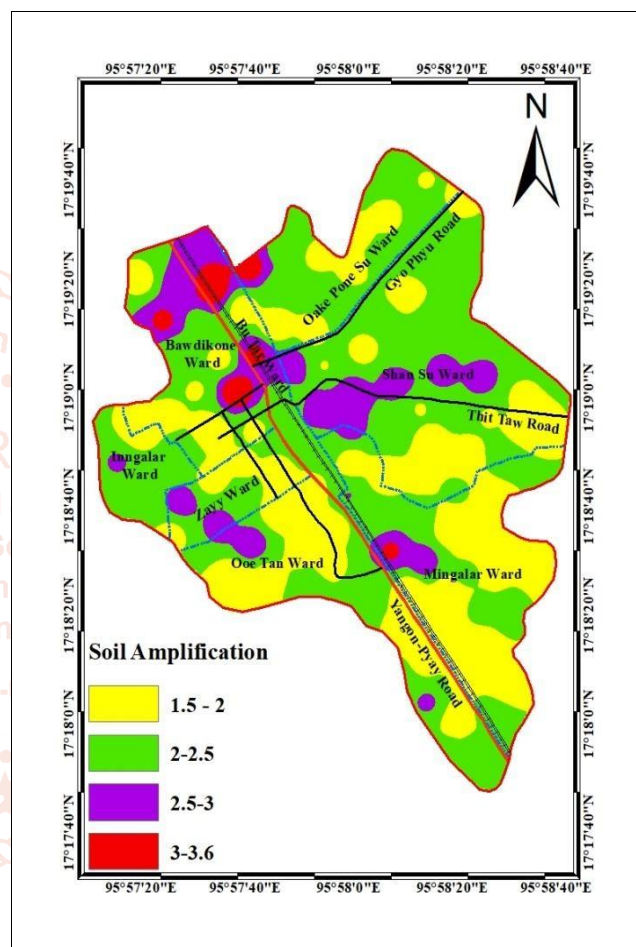


Fig.10 Peak Amplitude (Potential Soil Amplification) Map of Taikkyi Area

V. CONCLUSIONS

This research is intended to provide the reliable information about the local site effects of the Taikkyi area by using one of the geophysical approach of microtremor observations. The main outcomes of this research are fundamental frequency map and potential soil amplification map. The fundamental frequency is ranging from 1 to 2.3 Hz. High frequency represents that shallow soil layer is dominated and low buildings will experience stronger shaking during an earthquake whereas low frequency highlights that thicker soil layer is expected and high-rise buildings will experience stronger shaking than the low buildings. The variation of the peak amplitude (potential soil amplification) in Taikkyi area fall in the range of 1.5 to 3.6. Some high potential soil amplification zones are observed in this research area and after 2017 Taikkyi earthquake, the religious buildings in this zone were mostly affected by this earthquake. Therefore, the

level of ground shaking in this zone will be stronger than the other areas. The outcomes from this research are useful for not only engineering purposes but also mitigation of the seismic risk for Taikkyi area.

ACKNOWLEDGMENT

The author would like to acknowledge to my supervisor and professors from the Yangon Technological University who guided for this study and supported the instrument for microtremor measurements.

REFERENCES

- [1] S. L. Kramer, "Geotechnical Earthquake Engineering", Prentice-Hall International Series in Civil Engineering and Engineering Mechanics, 653 pp, 1996.
- [2] Myo Thant, "Probabilistic Seismic Hazard Assessment for Yangon Region, Myanmar", ASEAN Engineering Journal Part C Vol.3 No.2, December 2014.
- [3] Hla Hla Aung, Third Edition, 2017 "Myanmar Earthquake History", pp 114-125.
- [4] R. Tuladhar, F. Yamazaki, P. Warnitchai and J. Saita, "Seismic microzonation of the greater Bangkok area using Microtremor Observations", Earthquake Engineering and Structural Dynamics, 2004;33:211-225
- [5] D. Stankoa, S. Markusicb, S. Streleca, M. Gazdeka, "HVSr analysis of seismic site effects and soil-structure resonance in Varazdin city (North Croatia)", Soil Dynamics and Earthquake Engineering 92 (2017) 666–677
- [6] S. Aswad, M. A Massinai, Syamsuddin, "Microtremor Study of Site Effect for Disaster Mitigation and Geotechnical Purpose", the 2nd International Conference on Science (ICOS), 2018, 012053
- [7] M. H. Nokhandan, J. R. Rad, N. H. Moghaddas, "Site effects Evaluation in the Zabol City using Microtremor measurement", Proceedings of the 3rd IASME / WSEAS International Conference on Geology and Seismology

